Harmonizing human exposure and toxicity characterization

Fantke, Peter; Jolliet, O.; McKone, T.E.

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ABSTRACT BOOK

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found in surface samples, could then sink to the seafloor. Polyethylene was in fact found at the bottom of the sea already in 1975. A deeper understanding of these processes is imperative in order to design relevant monitoring programs and to interpret data from field-studies. A mesocosm experiment was therefore set up in June 2016 in the Gullmar fjord, Sweden. Polyethylene film without additives was pre-degraded to four different levels and added to stainless steel cages hanging in the water. Samples were taken every four weeks and analyzed to assess biofouling, degradation, fragmentation and changes in density. Already after four weeks the samples showed a 21% coverage of biofilm, which had increased to 38% after 8 weeks. The density increased with degradation and continued to increase throughout the tests, also when the biofilm was removed. Tests with FTIR showed changes among the carbonyl groups in the material that had been pre-degraded after four weeks in the water, it also revealed changes in crystallinity. The results indicate that degradation and biofouling will rapidly affect the floating capacity of the plastic in coastal areas and highlight the importance of including these factors to better interpret field collected samples and to predict the transportation and ultimate fate of plastic material in the ocean.

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Marine snows: a vector of transport of microplastic to the benthos and its biological implications.

A. Porter, University of Exeter / Biosciences; A. Watts, University of Exeter; B.P. Lyons, Cefas Weymouth Laboratory; T.S. Galloway, C. Lewis, University of Exeter / Department of Biosciences

Marine microplastics are so abundant, widespread and impacting on our marine environment that they have recently been suggested to represent a planetary boundary threat, alongside climate change and ocean acidification, yet our understanding of microplastic distributions and impacts remains limited. Whilst most of the research focus to date has look at the surface waters studies have shown benthic plastics can outweigh surface plastics by 400 times and indeed both deep sea sediments and organisms are now being found with microplastics in, including buoyant plastic types. We have been investigating marine snows as a potential vector for transporting microplastics of differing densities to the benthos. A range of plastics with varying forms (fragment, bead and fibre), polymers (PVC, PP, PA, PE, PS), and sizes (6 - 3000µm) were incorporated into marine snows using natural seawater placed in a tabletop roller. We demonstrate that both positively buoyant and negatively buoyant microplastic particles can be incorporated into marine snow; altering sinking rates and therefore their partitioning in the water column and importantly causing floating plastics to sink. We then tested whether plastics are more readily available to benthic filter feeders when incorporated into marine snow using a novel 2m feeding chamber to simulate a subtidal environment. We also show the incorporation of microplastics into marine snows alters the amount of plastics taken up by the filtering feeding mussel *Mytilus edulis* both through the change in sinking rate and in the bioconcentration of plastics within marine snows. Mussels were shown to uptake more plastic when incorporated into marine snows than when placed with just free plastics. Our work provides novel evidence that marine snows are a viable vector for the transport of microplastic pollution from the surface waters to the benthos including plastics from the buoyant fraction and this mechanism will change the partitioning and uptake of microplastic pollution in the water column.

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Desorption of organic wastewater contaminants from microplastic particles in presence of natural dissolved substances

S. Seidensticker, G. Fellenberg, University of Tuebingen / Center for Applied Geosciences; C. Zarfl, University of Tubingen / Center for Applied Geosciences; P. Grathwohl, Uni Tübingen / Center for Applied Geosciences

Microplastic particles (MP) are ubiquitously detected within all environmental compartments. Besides likely impairments due to their mere presence they might impact the ecosystem through leaching of additives and facilitated transport of contaminants. Several studies showing their potential to take up hydrophobic organic contaminants have been published. However, sorption behaviour of contaminants to MP in presence of further natural material, e.g. to reflect environmental conditions in freshwaters, has been neglected so far. Therefore, this study aims to investigate the sorption properties of MP and their changes due to the presence of natural occurring sorbents. As representative plastic material, polyethylene which is among the most produced and detected plastic types was chosen. Humic acid (HA) is a common type of dissolved organic matter and was hence used as a typical natural material. Sorption interactions were studied in batch experiments with a constant concentration of MP (1 g/L) and different concentrations of HA (0, 0.15, 0.25, 0.50, 0.75, 1.00 g/L). MP were previously spiked with common wastewater pollutants allowing both to study desorption from MP and to monitor sorption to HA in dependence of its concentrations. Samples were taken at 12 times from 10 min to 240 h. Log partition coefficients between MP and water were 3.98, 4.46, and 3.79 for phenanthrene, tonalide, and 4-*n*-nonylphenol (4-*n*-NP), respectively. The mean log partition coefficients between HA and water were, 3.74 for phenanthrene, 3.92 for tonalide, and 4.02 for 4-*n*-NP. In equilibrium, increasing amounts of HA go along with a decreasing fraction sorbed to MP and a decreasing freely dissolved fraction, but an increasing total dissolved fraction. Considering this, the partitioning between MP and water is remarkably influenced by the present amount of HA. Further analysis of the kinetics revealed a faster desorption from MP but also an extended time to reach equilibrium due to enlarged mass transfer. Additional modelling indicated that the external mass transfer resistance, i.e. the thickness of the water boundary layer around the MP, limited the diffusion if no or small amounts of HA are present. With increasing amounts of HA, desorption kinetics was more and more governed by intrapolymer diffusion, i.e. the diffusive flux within the MP is decisive. Thus, high amounts of HA in freshwaters lead to an increased release of pollutants and, however cause a shift towards slower kinetics.

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Do microplastics really act as vectors of organic pollutants to marine zooplankton? Experiments with pyrene and nonylphenol spiked polyethylene using Paracentrotus lividus larvae.

R. Beiras, Universidade de Vigo / Ecology and Animal Biology; S. Pérez, O. Nieto, University of Vigo; N. Salgueiro-González, University of A Coruña

Previous work has demonstrated the ingestion of microplastics (MPs) by marine zooplankton and raised concern about the potential role of MPs as vectors of adsorbed non-polar organic toxicants to planktonic filter feeders. We have tested this hypothesis using a standard marine toxicity test, the sea-urchin embryo test, modified to introduce into the incubation vials and keep in suspension low-density polyethylene microparticles of 2 to 20 μm, the appropriate size range to be ingested by these organisms. Apart from sea-water and solvent controls, and waterborne toxicants, additional treatments include virgin MPs and MPs previously spiked with several well known non-polar organic toxicants, including pyrene and 4-nonylphenol. The experimental set-up included dosage of the toxicants at two levels (ca 1/10 x and 1x toxicity threshold for this test species) via both dissolved phase and in the presence of MPs. Microscopic observation documented ingestion by the presence of larval stomachs filled with MPs. However, in none of the experiments up to date the presence of MPs increased the toxicity of the non-polar pollutants to these highly sensitive biological models, compared to the waterborne treatments. These results do not support any role for MPs as vectors of potentially harmful organic pollutants to zooplanktonic organisms.

Increasing the relevance of toxicity assessment in LCA: in the need for a cross fertilization between RA and LCA (II)

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Harmonizing human exposure and toxicity characterization

P. Fantke, Technical University of Denmark / Quantitative Sustainability Assessment Division; O. Jolliet, University of Michigan; T.E. McKone, University of California / School of Public Health

The UNEP-SETAC Life Cycle Initiative has launched a project to provide global guidance and build consensus on environmental life cycle impact assessment (LCIA) indicators. Human health effects from exposure to toxic chemicals was selected as impact category due to high relevance of human toxicity impacts, past and present efforts in human toxicity assessment, and the need for further harmonization and global guidance. To address this need, an expert workshop was implemented in Utrecht in October 2016 with the aim of building a roadmap for a reliable and consistent approach for improving and harmonizing human toxicity characterization in LCIA. Building on initial work for the far-field and indoor air environments, and combining it with latest work on near-field consumer and occupational exposure assessment, dose-response and severity data, we aim at providing revised guidance on the development and use of impact factors for toxic chemicals. We propose to couple fate processes in consumer and occupational environments with existing environmental compartments and processes via a consistent and mass balance-based set of transfer fractions to quantify overall aggregated exposure to toxic substances. We propose the product intake fraction (PiF) as metric linking human intake via all exposure routes to substance mass in products. Further, for fine particulate matter, a constructed integrated exposure-response model has recently been proposed and applied to calculate marginal and average health impacts, which will serve as starting point for improving toxicity dose-response. To go beyond the additivity and linearity assumptions and to address essentiality and vulnerability, we propose to account for the fraction of population that is above a certain risk threshold for the considered disease/mode of action. We finally propose to explore the possibility to expand the endpoint coverage beyond cancer and non-cancer and to differentiate between other relevant health effects. For attributing severity to mortality (and morbidity) for cancer and non-cancer diseases to damage metrics, we will need to identify severity weights for population disease incidences expressed as disability-adjusted life years (DALY). All aspects for fate and exposure outdoors, consumer and occupational exposure, toxicity effects and dose-response, and cross-cutting issues are currently being further detailed aiming at arriving at recommended factors and global guidance within the next two years.

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A method for application-specific human health risk estimation from chemical exposure in an LCA context

T. Rydberg, J. Lexén, C. Loh Lindholm, E. Lundström Belleza, IVL Swedish